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Astronomy Group

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Research Activities

(I) STAR

a. Stellar Structure and Evolution

M.NAKAMURA and Y.NAKAMURA[1] were calculated evolutionary models of the early-type contact binary SV Centauri. Two types of the contact condition were employed to treat the contact phase. The results have shown that, with the initial masses of 13.4 and 7.0 $M_{\odot}$ for the component stars, the observed features such as the rate of mass transfer, the degree of contact, and the positions of both components in the H-R diagram can be reproduced. This indicates that the binary system SV Cen is actually in the rapid phase of mass transfer preceding the reversal of the mass ratio. As soon as the system evolves into the contact phase, the rate of mass transfer suddenly turns to decrease. This decreasing character continues until the rate drops to a minimum. In such contact phase the radius of the primary component remains almost unchanged, the second component increases its radius slowly, and the degree of contact increases in a definite way. Except a slight difference in the degree of contact evaluated, the use of different expressions for the contact condition does not produce practically any appreciable difference in the results.

b. Pulsating Stars

TANAKA, ARIMOTO and TAKEUTI[2] have presented a short note on the thermal instability of hydrogen burning shells in very massive stars to IAU Colloquium No. 59. The details of their procedure and some idea on β Cephei stars are described in their another paper[3]. They have modified the one zone model to

include the nuclear energy sources and Sackmann's geometrical measure m_s. The deviation of physical quantities from the equilibrium values for entropy perturbations have been analytically obtained mainly in terms of m_s and the exponent of the temperature in the nuclear energy production rate n. The conditions that the entropy perturbations grow are : 1) $m_s < 0.4$ and $n \gtrsim 3$ and 2) $m_s \gtrsim 2$ and $n \gtrsim 14$ for the hydrogen burning shell and electron scattering, if the effects of radiation pressure are neglected. In the first case, the increase of the temperature in the shell, the decrease of the position of the shell, and the increase of the shell density are induced by the increase of entropy, whereas the second case of thermal instability agrees with the current theory. A mechanism for β Cephei pulsations is suggested concerning the first case of thermal instability.

To investigate resonance phenomenon in classical cepheids, TAKEUTI and AIKAWA[4] have studied the non-linear radial oscillation of stars based on the assumption that the non-adiabatic perturbation is expressed in terms of van der Pol's type damping. Two- and three-wave resonance in this system has been applied to classical cepheids to describe their bump and double-mode behavior. The phase of bump and the depression of amplitude are explained for bump cepheids. The double-periodicity is shown by the enhancement of the third overtone in three-wave resonance. Non-linear effect on resonant period has also been discussed briefly.

TAKEUTI[5] has presented a report on the resonance theory to the workshop on pulsating B stars held at Nice Observatory. The essential results of recent studies about resonant pulsations of stars have been briefly described.

c. Stellar Magnetosphere

NAKAJIMA[6] has presented a model to explain the Hα emission of helium-rich stars. It has been proposed that the circumstellar gas of helium-rich stars will be trapped in the outer region of stellar magnetosphere where the centrifugal force dominates. Only in rapidly rotating stars, the outer region can contain the gas much enough to emit the observed Hα emission energy flux. It has been shown that, as the circumstellar gas corotates with the star, Hα emission profile becomes very broad and so the emission appears in the wing of Hα absorption line which originates in the photosphere of star.

It has often been suggested that the inertial effects of the magnetospheric plasma should be taken into consideration in order to obtain a globally self-consistent solution for the stellar magnetosphere. As an asymptotic solution in the near zone, KABURAKI[7] derived the corotating-plasma solution by including only the ion mass simultaneously in the equation of motion and the generalized Ohm's law. The characteristic distance beyond which the corotation approximation breaks down was expressed in terms of the physical quantities at the stellar surface. The bending of the magnetic equator toward the rotational one was shown to arise in an oblique-rotation case due to the centrifugal force.

KABURAKI also took the effects of electron mass into account up to the first order terms in the mass ratio $\delta = m_-/m_+$. This is the lowest order approximation for the electron mass, in which the drift current can be determined self-consistently. It was pointed out that even in the corotating region the drift current can modify the stellar magnetic field to form a magnetodisk structure, and one such disk solution was obtained self-consistently.

An attempt is being made by SHIBATA to obtain the numerical solution to the magnetospheric structure with stellar wind. As a first step, the motion of tenuous plasma under the vacuum electric and magnetic fields was investigated.

KABURAKI and IMAI inferred the structure of the heliospheric current sheet based on a phenomenological model in which the magnetic distribution on the solar surface is propagated by a spherical MHD wave. Transition between the four-sectored and two-sectored structure in the interplanetary magnetic field was explained by the combination of a solar centered dipole moment and an equatorial quadrupole moment.

Publications

1) Evolutionary Computations of Early Type Contact Binary SV Centauri, N. Nakamura and Y. Nakamura, Astrophys. Space Sci. 83 (1982) 163 = Sendai Astronomiaj Raportoj N-ro.243.
2) Thermal Instability of Hydrogen-burning Shell in Very Massive Stars, Y. Tanaka, N. Arimoto and M. Takeuti, 'Effects of Mass Loss on Stellar Evolution', ed. by C. Chiosi and R. Stalio, D. Reidel Publ. Co. (1981) 289.
3) Thermal Instability of Hydrogen-burning Shell in Very Massive Stars, Y. Tanaka, N. Arimoto and M. Takeuti, Sci. Rep. Tohoku Univ. 8th Ser. 2 (1981) 16 = Sendai Astronomiaj Raportoj N-ro.233.
4) Resonance Phenomenon in Classical Cepheids, M. Takeuti and T. Aikawa, Sci. Rep. Tohoku Univ. 8th Ser. 2 (1981) 106 = Sendai Astronomiaj Raportoj N-ro. 239.
5) The Resonance Theory of Pulsating Stars, M. Takeuti, 'Proceedings of Warkshop on Pulsating B Stars', Observatoire de Nice (1981) 389.
6) The Hα Emission of Helium-rich Stars, R. Nakajima, Sci. Rep. Tohoku Univ. 8th Ser. 2 (1981) 130 = Sendai Astronomiaj Raportoj N-ro.240.
7) Determination of the Electromagnetic Field Produced by a Magnetic Oblique-Rotator IV. Corotating-Plasma Solution (2), O. Kaburaki, Astrophys. Space Sci. 82 (1982) 441 = Sendai Astronomiaj Raportoj N-ro.241.

(II) INTERSTELLAR MATTER

YOSHII[1)] explained the absence of metal-free or extremely metal-deficient halo stars by a hypothesis of enrichment of stellar surface metal abundances due to accretion of metal-rich material through encounters with interstellar gas clouds. It is suggested that the correlation between metal abundance and stellar age is violated for the stars with circular orbit by the effect of

accretion.

HASEGAWA, YOSHII and SABANO[2] investigated the thermal evolution of a hydrogen gas cloud which contracts by self-gravitation in the pre-galactic stage and found that the mass range for the first-generation stars was to be 0.1-20 $M_{\odot}$.

YOSHII[3] considered with FUJIMOTO (Nagoya University) a hydrodynamical interaction between the disk and halo of the galaxy in differential rotation. The condition is derived from the disk-halo system that the bending oscillation is unstable. The characteristics of the unstable modes may account for the large-scale asymmetric flexure of the isolated galaxies.

Publications

1) Metal Enrichment in the Atmospheres of Extremely Metal-deficient Dwarf Stars by Accretion of Interstellar Matter, Y. Yoshii, Astron. Astrophys. 97 (1981) 280 = Sendai Astronomiaj Raportoj N-ro.228.
2) Thermal Evolution of a Contracting Hydrogen Gas Cloud, T. Hasegawa, Y. Yoshii and Y. Sabano, Astron. Astrophys. 98 (1981) 186 = Sendai Astronomiaj Raportoj N-ro.232.
3) A Hydrodynamic Interaction Between the Galactic Disk and Halo, and Its Application to the Origin of Warping Gaseous Disks, Y. Yoshii and M. Fujimoto, Astron. Astrophys. 104 (1981) 142 = Sendai Astronomiaj Raportoj N-ro.237.

(III) OBSERVATIONS AND EXPERIMENTS

All observational works were performed at Okayama Astrophysical Observatory, Kiso Observatory, and Dodaira Station of Tokyo Astronomical Observatory which belong to University of Tokyo.

Spectroscopic studies on Markarian galaxies have been continued by TANIGUCHI and TAMURA[1]. The main purpose of them is to clarify the present status of UV excess property in different type of galaxies, in particular non-Seyfert Markarians. They completed their work on the galaxy Markarian 297 which shows peculiar structure and consists of a number of clumps. Their results are (i) emission lines come from dusty HII regions similar to those in the outer arms of Sc galaxies, (ii) the number of OB stars of the order of 10^5 is required as ionizing sources. TANIGUCHI and TAMURA[2] also observed the galaxy Markarian 914 as a sample of clumpy irregular galaxies which shows sharp emission lines. However, it is concluded that Markarian 914 is a galactic object, Lick Hα233, and it should be deleted from the list of Markarian galaxies.

TAMURA[3,4] published papers on peculiar emission line star, HBV 475 = V1329 Cyg which has a symbiotic nature. The most interesting character of this object is the time variation of spectroscopic features. From the data obtained in the term of 1974-1978, he could find the temperature variations of the central exciting star in the range of 120,000 K-180,000 K. Since the estimated ionizing

zone become extremely larger than the proposed binary system, he doublts the binary hypothesis. TAMURA also found a single star hypothesis is preferable to explain the line profiles of [FeVII]6087, HeI6687, and Hα by the interacting stellar winds model of the Planetary Nebula formation.

ISHII and TAMURA[5], in collaboration with T.YAMAMOTO of the Institute of Space and Astronautical Science, completed a paper on Comet 1973 XII Kohoutek. They derived the vibrational temperature of C_2, the total numbers of CN and of C_2, and the production rates for CN and C_2 from the observed fluxes by photoelectric spectrophotometric scans. In their conclusions, it can be supported that C_2 is formed via two-step photodissociation rather than one-step photodissociation.

This year HASEGAWA and TAKAKUBO with M.SEKI of College of General Education began to study the structure and the evolutional status of Bok globules and their association with the ambient interstellar medium with the aid of multi-channel polarimeter at Okayama Astrophysical Observatory and Dodaira Station of Tokyo Astronomical Observatory.

Publications

1) The Observational Properties of the Galaxy Markarian 297, Y. Taniguchi and S. Tamura, Publ. Astron. Soc. Japan 33 (1981) 653 = Sendai Astronomiaj Raportoj N-ro.238.
2) Markarian 914 is a Galactic Object, Lick Hα233, Y. Taniguchi and S. Tamura, Astrophys. Letters (1982) in press.
3) Activity of HBV 475 from its Spectral Variations, S. Tamura, Publ. Astron. Soc. Japan 33 (1981) 699 = Sendai Astronomiaj Raportoj N-ro.242.
4) An Expanding Motion in the Ionized Envelope of HBV 475, S. Tamura, Astrophys. Letters 22 (1981) 35 = Sendai Astronomiaj Raportoj N-ro.244.
5) Spectrophotometric Scan of Comet 1973 XII Kohoutek, H. Ishii, T. Yamamoto and S. Tamura, The Moon and Planets 25 (1981) 737 = Sendai Astronomiaj Raportoj N-ro.235.

Master Thesis (March 1982)

M1) Chemical Abundances of Planetary Nebulae, Katsunori Shibata.